Monitoring for Potential Effects of the Gold King Mine Release on Water Quality in the Animas and San Juan Rivers in New Mexico using Continuous Monitors and Automatic Samplers

A work plan prepared by the U.S. Geological Survey for the New Mexico Environment Department

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Summary

On August 5, 2015, about three million gallons of water and sediment were released from the Gold King Mine (GKM) near Silverton, Colorado, into Cement Creek, a tributary of the Animas River. The New Mexico Environment Department, among other State, Tribal, and local entities in CO, NM, and UT, is concerned that metals associated with the water and sediment released from the Gold King Mine could have long-term detrimental effects on surface-water quality of the Animas and San Juan Rivers, with potential risks to human health and the environment. The USGS, in cooperation with the New Mexico Environment Department, proposes to collect, analyze, and report surface-water quality data to characterize post-release conditions. The objectives of the study are to provide data that will improve the understanding of post-GKM-release surface-water quality for the Animas and San Juan Rivers under a variety of hydrologic conditions, including during high-flow events, and to provide real-time data on flow and field parameters that affected stakeholders can use to take whatever actions they feel might be necessary to protect public health. To accomplish these objectives, for a period of one year at four sites on the Animas and San Juan Rivers, the USGS will conduct continuous monitoring of water-quality parameters and will collect integrated water-quality samples during snowmelt runoff for analysis of major ions and dissolved and total metals. One site also will be instrumented with an automatic sampler to

collect water-quality samples during snowmelt and storm events for analysis of major ions and total metals. The resulting data will be available through the National Water Information Systems database and its associated Web applications. Depending on the resulting data and the availability of future funding, a potential second phase of data collection extending beyond one year could be added, along with a formal publication describing the results and providing data interpretation.

Background

On August 5, 2015, about three million gallons of water and sediment were released from the Gold King Mine (GKM) near Silverton, Colorado, into Cement Creek, a tributary of the Animas River (U.S. Geological Survey, 2016). The release occurred during excavation that was being conducted as part of an investigation by the U.S. Environmental Protection Agency (EPA) into on-going water releases from the mine and the feasibility of water treatment and further mine remediation (U.S. Environmental Protection Agency, 2016). The Gold King Mine, which operated between about 1887 and 1922, is one of numerous abandoned and inactive mine sites that contribute metals and acidity to the Animas River and many of its tributaries (U.S. Environmental Protection Agency, 2015).

Low pH values (less than 3) and elevated concentrations of iron, aluminum, cadmium, copper, lead, zinc, arsenic, and (or) nickel are associated with water most affected by historical mining in the area as a result of water flowing through mine workings, across mine-waste dumps, and over and through mill tailings (U.S. Geological Survey, 2007a). Historical mining also has affected the distribution and concentration of metals in streambed sediments (U.S. Geological Survey, 2007a). However, weathering of hydrothermally altered

rock not associated with historical mine sites is a substantial natural source of metals and acidity to area streams, as well (U.S. Geological Survey, 2007a; U.S. Environmental Protection Agency, 2015). Previous studies by the U.S. Geological Survey (2007a) attempted to characterize geochemical conditions in the Animas River watershed prior to mining, and by extension to identify the primary effects of historical mining; efforts intended to determine the percentage of trace-element loads that could be attributed to weathering of undisturbed areas had mixed results. The potential short- and long-term water-quality effects of relatively sudden and large releases of mining-related water and sediment, such as the release that recently occurred at the GKM, are not known to have been previously studied in this watershed.

Downstream of Cement Creek, the Animas River flows primarily southward through Durango in southwestern Colorado and into northwestern New Mexico, where the Animas River joins the San Juan River near Farmington (fig. 1). The San Juan River then flows northwest through the Navajo Nation and into Utah, where it discharges into Lake Powell. The public water systems of Aztec and Farmington, among others, rely on the Animas River as their primary source of drinking water. Waters of the Animas and San Juan Rivers also are used for crop irrigation. Diversions for public supply and crop irrigation were halted for about 10 days after the GKM release. When restrictions on the use of river water were lifted, New Mexico State Secretary Ryan Flynn indicated that river water quality had returned to pre-release levels, but that long-term impact studies were needed to determine the full effects of the release (Lohmann, 2015). EPA Regional Director Shaun McGrath similarly indicated that ongoing monitoring would be required to determine long-term impacts on water quality,

particularly related to metals associated with sediments that settled onto the streambed and could be remobilized during storm surges or flooding events (Moreno and Billeaud, 2015).

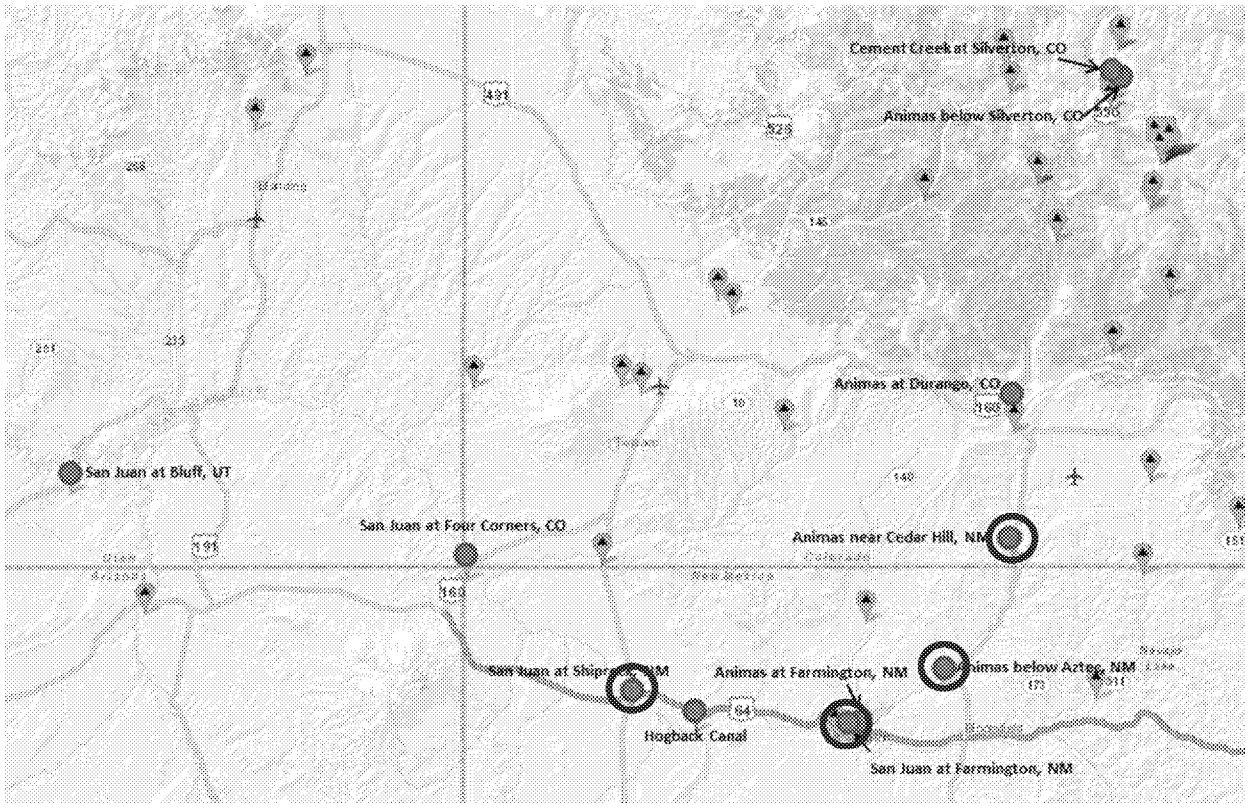

Figure 1. Locations of USGS streamflow gaging stations on Cement Creek and the Animas and San Juan Rivers downstream of the Gold King Mine release. Proposed monitoring sites are circled in red.

Preliminary analysis by the New Mexico Environment Department (NMED) of monitoring data collected by the EPA and the City of Farmington since the GKM release indicates that concentrations of total metals in the Animas and San Juan Rivers can increase to "levels of concern" during high-flow events, and that high turbidity during such events might be associated with total lead concentrations exceeding the EPA Action Level of 15 micrograms per liter for treated drinking water (Dennis McQuillan, Chief Scientist, New Mexico Environment Department, written commun., January 15, 2016). Because of potential issues indicated by analysis such as this, the NMED, among other State, Tribal, and local entities in

CO, NM, and UT, is concerned that the GKM release could have long-term detrimental effects on surface-water quality of the Animas and San Juan Rivers, with associated risks to human health and the environment. Therefore, the NMED has proposed a long-term monitoring plan that would involve multiple Federal, State, and local entities in assessing various aspects of the surface-water and groundwater systems along with ecological health (Dennis McQuillan, Chief Scientist, New Mexico Environment Department, written commun., January 15, 2016).

Problem

The NMED and other stakeholders lack the information required to understand post-GKM-release surface-water quality under varying conditions. Without an improved understanding of water quality, NMED and other stakeholders are unable to determine any actions that might be appropriate to protect public health and the environment.

Objectives and Scope

The NMED requested that the USGS participate in the multi-agency long-term study that the NMED has proposed to assess various aspects of the hydrologic systems along the Animas and San Juan Rivers subsequent to the GKM release. The proposed USGS part of the study has two primary objectives. The first objective is to provide data that will improve the understanding of post-GKM-release surface-water quality, and particularly of concentrations of dissolved and total metals, for the Animas and San Juan Rivers under a variety of hydrologic conditions, including during high-flow events. Given that the current understanding of the effects of high-flow events and mobilization of sediments on surface-water quality is not sufficient to fully characterize potential implications for public health, the

second objective is to provide real-time data on flow and field parameters, including turbidity, that affected stakeholders in CO and NM can use to take whatever actions they feel might be necessary (such as shutting down source-water intakes to public-water systems) to protect public health and drinking-water treatment infrastructure during high-flow events. Funding currently (February 2016) is available for initial data collection at four sites for a period of one year. Based largely on the locations of drinking-water and irrigation diversions, sites have been selected to extend from the Animas River near Cedar Hill, NM to the San Juan River at Shiprock, NM (fig. 1). Depending on the resulting data and the availability of future funding, a potential second phase of data collection extending beyond one year could be added, along with a formal publication describing the results and providing data interpretation.

Relevance and Benefits

The August 5, 2015 release of water and sediment from the GKM was a high-profile event with documented short-term water-quality impacts and the potential for long-term impacts in at least three States (CO, NM, and UT). This study will provide data about the quality of surface water in the Animas and San Juan Rivers to the NMED and to other State and Federal agencies responsible for managing natural resources and providing hazard mitigation. Improvement of understanding of post-GKM-release surface-water quality also will benefit State, Tribal, and local stakeholders that use the water for municipal, agricultural, recreational, and cultural purposes. Several of these stakeholders have expressed concern about the potential for long-term impacts of the GKM release on their use of water, and have indicated a need for greater availability of water-quality data. This study will provide data

collected by the USGS that are publicly available, which aligns with the USGS Mission to provide non-biased scientific information to the public.

This study contributes to the goals of the USGS strategic science direction " The Role of Environment and Wildlife in Human Health" (U.S. Geological Survey, 2007b) and the USGS Water Census Strategic Science Direction in providing information about the status of the Nation's water availability and use (Evenson and others, 2012). The study addresses the legacy and potential future effects of mining, which is a priority issue for both the USGS Water Mission Area and the USGS Water Science Centers in Colorado and New Mexico, as evidenced by previous studies of the effects of mining in the Animas River watershed, which involved collaborators from multiple USGS disciplines.

Approach

The general approach to providing data that will improve the understanding of post-GKM-release surface-water quality involves (1) installation of water-quality instrumentation at existing USGS gaging stations downstream of the GKM release, and (2) collection and reporting of continuous and discrete water-quality data at those gaging stations. Funding currently is available to begin data collection at four sites. The following sites were selected for initial data collection based partly on proximity to drinking-water and irrigation diversions:

- Animas River near Cedar Hill, NM (09363500);
- Animas River below Aztec, NM (09364010);
- San Juan River at Farmington, NM (09365000);
- San Juan River at Shiprock, NM (09368000).

Water-quality sondes with pH, temperature, specific conductance, and turbidity probes will be installed at all four gaging stations, and an automatic sampler will be installed at the

gaging station on the Animas River below Aztec, NM. Integrated water-quality samples will be collected at all 4 stations on three occasions during snowmelt runoff. Equipment operation and data collection will continue for one year, with the potential (depending on initial data results and the availability of future funding) for a second phase of the study that would extend data collection beyond one year and add a formal publication describing the results and providing data interpretation. The resulting data will be made available through the USGS National Water Information System (NWIS) database. USGS New Mexico Water Science Center personnel will install and operate the equipment at all four stations. USGS safety procedures will be followed at all times.

1. Equipment installation

Water-quality sondes will be purchased and installed at the four USGS gaging stations prior to (or as close as possible to the start of) 2016 snowmelt runoff. The sondes will be equipped and operated to collect data at 1-hour intervals for four parameters: water temperature, pH, specific conductance, and turbidity. During the same time frame, an automatic sampler (such as the one manufactured by ISCO) will be purchased and deployed at the gaging station on the Animas River below Aztec, NM. The sampler will be programmed to collect water-quality samples for investigation of surface-water quality during snowmelt and storm events.

2. Data collection and reporting

The water-quality sondes will be visited at least every six weeks for maintenance and calibration as needed. The data for the four water-quality parameters (water temperature, pH, specific conductance, and turbidity) will be transmitted in real time to the NWIS database, where they will be available through the NWISWeb and WaterQualityWatch web sites. The

USGS currently (2016) measures discharge at all three gaging stations; these data are available through the NWISWeb and WaterWatch websites. In addition, the USGS WaterAlert service will be available for subscription e-mail and text alerts to the public when discharge and (or) water-quality measurements exceed user-specified levels.

Integrated water-quality samples will be collected at all four USGS gaging stations on three occasions during snowmelt runoff. Sample collection will be timed to correspond with (1) the first significant snowmelt event of the year that causes the river to rise above flow conditions that existed during the GKM release (~800 cfs); (2) peak snowmelt in the Cement Creek watershed; and (3) recession of the snowmelt hydrograph, which causes flow to dip below flow conditions that existed during the GKM release. Samples will be submitted using NWQL Chain of Custody procedures for analysis of major ions and dissolved and total metals under laboratory schedule 2642. Samples also will be analyzed for suspended-sediment concentration by the New Mexico Water Science Center Sediment Laboratory. Field and laboratory results will be loaded into the NWIS database, where they will become readily accessible to the public through the NWISWeb application.

The automatic sampler on the Animas River below Aztec, NM will be programmed to collect water-quality samples under certain conditions during snowmelt and storm events. During snowmelt, samples will be collected under the same snowmelt runoff conditions specified above for the collection of integrated samples. Four samples will be collected at different times under each of the three specified sets of conditions (beginning, peak, and recession of snowmelt runoff), for a total of 12 snowmelt related samples during the year. Storm related sampling events, which are anticipated to occur primarily during the summer to fall monsoon season, would attempt to capture conditions (1) prior to the storm (if possible); (2) during the

storm (on the rising limb of the hydrograph); and (3) on the falling limb of the hydrograph for three storms during the year, as the frequency of storms allows. Four samples will be collected during each of the storm sampling events, for a maximum of 12 storm related samples during the year.

Water-quality samples collected by the automatic samplers will be retrieved within three days of collection and processed using clean-sampling procedures (U.S. Geological Survey, variously dated) within four days of collection for shipping to the USGS National Water Quality Laboratory (NWQL). Samples will be submitted using NWQL Chain of Custody procedures for analysis of major ions and total metals. Laboratory results will be loaded into the NWIS database, where they will become readily accessible to the public through the NWISWeb application.

Quality Assurance/Quality Control

Data collection, storage, review, approval, and reporting will conform to USGS Fundamental Science Practices and the Water-Quality Quality-Assurance Plan of the New Mexico Water Science Center.

The water-quality sondes will be operated and maintained as described in Wagner and others (2006). Provisional data from the sondes will be transmitted and made available through NWIS web applications in real time. The data will be checked multiple times per week for clearly erroneous values that would result in appropriate data censoring and (or) maintenance visits to the affected site(s). The data will be scheduled for working (application of data corrections), checking, and review/approval within 150 days of collection. Cross-section

surveys of water-quality parameters will be conducted annually at each site to characterize cross-section variation and vertical stratification.

Collection and processing of integrated water samples and of samples obtained by the automatic sampler will follow standard procedures described in the USGS National Field Manual for the Collection of Water-Quality Data (U.S. Geological Survey, variously dated). Provisional water-quality results will be loaded into NWIS and made available through NWIS web applications as reported by the laboratories. Once all data have been reported for individual samples, they will be reviewed and approved as appropriate.

To evaluate the representativeness of the point samples collected by the automatic sampler on the Animas River below Aztec, NM relative to water quality across the stream profile, the three integrated samples will be collected concurrently with automatic samples obtained during snowmelt runoff. Because this USGS study is one part of a multi-agency NMED monitoring plan that includes proposed collection of quarterly grab samples by the San Juan Soil and Water Conservation District (SJSWCD) for similar constituents at the same USGS gaging stations, if the SJSWCD sampling is funded, splits of two sets of integrated USGS samples will be sent to the laboratory that is being used by the SJSWCD to evaluate comparability of results between laboratories. Standard reference samples also will be submitted to the laboratory used by the SJSWCD to facilitate evaluation of comparability and performance. Additional quality-control samples collected by the USGS in association with integrated samples and with operation of the automatic sampler will include blank samples (equipment, field, and source-solution) and replicates.

Products

The product for this study will be the water-quality and suspended-sediment data collected by means of the water-quality sondes, integrated samples, and automatic sampler at the existing USGS gaging stations as described. These data will be made available through the NWIS database and its associated Web applications. If funding becomes available for a second phase of study, a formal USGS publication of data results and interpretation could be added.

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Budget and Timeline

The proposed study will be conducted during Federal Fiscal Years 2016-17. A detailed timeline for the study is provided in the table below, assuming a start date of February 22, 2016.

Task	FY2016			FY2017	
	Q2*	Q3	Q4	Q1	Q2
1. Equipment installation (sondes and automatic samplers)	X	X			
2. Data collection and reporting					
Water-quality sondes:					
Service water-quality sondes		X	X	X	X
Work, check, approve continuous water-quality data in NWIS		X	X	X	X
Integrated water-quality samples:					
Collect snowmelt related samples for laboratory analysis	X	X	X		
Review and approve field/laboratory data in NWIS		X	X	X	X
Automatic sampler:					
Collect snowmelt related samples for laboratory analysis	X	X	X		
Collect storm related samples for laboratory analysis		X	X		
Review and approve field/laboratory data in NWIS		X	X	X	X

*Quarters corresponding with months as follows: 1 = Oct.-Dec., 2 = Jan.-Mar., 3 = Apr.-Jun., 4 = Jul.-Sept.

The study will cost $224,800. Study costs will be jointly funded by the NMED and the USGS New Mexico Water Science Center, which will contribute cooperative matching funds. Study funds will cover all salary and other expenses to support the objectives and approach detailed in this proposal.

Funding

Agency	FY2016	FY2017
USGS	$ 17,960	$ 2,840
NMED	$176,150	$ 27,850
Total	$194,110	$ 30,690

Expenses

Category	FY2016	FY2017
Labor	$ 41,190	$ 11,785
Supplies	$ 3,040	$ 1,000
Equipment	$ 52,000	$ -
Laboratory	$ 30,700	$ -
Travel	$ 4,500	$ 1,565
Vehicle/fuel	$ 2,750	$ 1,435
Shipping	$ 600	$ -
Indirect costs	$ 59,329	$ 14,905
Total	$194,110	$ 30,690

Personnel

Employee	Hours FY2016	Hours FY2017
Hydrologist, GS-11	85	30
Hydrologic Technician, GS-11	620	330
Hydrologist, GS-9	20	0
Hydrologic Technician, GS-9	25	0
Hydrologic Technician, GS-5	305	135